
ENERGY SYSTEMS
TEST AREA (ESTA)
POWER SYSTEMS
TEST FACILITIES
ENERGY SYSTEMS DIVISION
NASA • JSC
National Aeronautics and
Space Administration
NASA

JOHNSON SPACE CENTER (JSC)

Energy Systems Test Area (ESTA)

- Isolated from main JSC campus
- Safety provisions to accommodate hard failures and hazardous conditions

POWER SYSTEMS FACILITY

- **Located in the Energy Systems Test Area (ESTA) - Bldg 361**
  - 1 MVA of facility power
    - 450 kVA of clean, isolated, monitored, power
  - 45 tons of cooling
  - Humidity control
  - Access control

•East Side

•North Side

•South Side

POWER TESTING

- **Flight Testing:**
  - Acceptance testing on hardware before flight
  - Involves independent verification from Quality Control
  - Support Shuttle and Station projects
- **Development Project Support:**
  - Power systems research
  - Power system component and system development and testing

POWER TEST EQUIPMENT CAPABILITIES SUMMARY

- **Sources:**
  - •8 to 445 VDC, ±530 ADC, 125 kW
  - •5 to 120 VDC, ±500 ADC,30 kW
  - •300 VDC, 200 ADC, 60 kW
  - •50 kVDC, 24 mADC, 1200 W
  - •Various DC and AC sources
- **Loads:**
  - •24 - 300 VDC, 100 ADC, 30 kW
  - •0 – 40 VDC, 360 ADC, 10 kW
  - •120 VDC, 1200 ADC, 6000 W
  - •150 VDC, 33 ADC, 165 W
  - •500 VDC, 150 ADC, 1000 W
  - •Various DC and AC loads
- **Test Equipment:**
  - •Calibrators
  - •Spike Generators
  - •Scopes
  - •Digital Multimeters
  - •Spectrum Analyzers
  - •Dielectric Analyzers
  - •High Voltage Switching Units
  - •Low Voltage Switching Units
  - •High Speed Data Systems
  - •Power Amplifiers
  - •Impedance Analyzers
  - •Data Acquisition and Control Systems
  - •Thermal Imagers
  - •Microscope Camera System
  - •Chillers

SOURCE / LOAD

- **AeroVironment**
- **Dual Channel Cycling Stations**
- **ABC-150**
  - 8 to 445 VDC, ±530 ADC, 125 kW
  - Quantity: 2
- **MT-30**
  - 5 to 120 VDC, ±500 ADC, 30 kW
  - Quantity: 1

SOURCE

- **Lamda EMI Inc**
  - DC Regulated High Power Supplies
  - EMHP300-200D42214
    - 300 VDC, 200 ADC, 60 kW
    - Quantity: 2
  - EMHP150-130D42211
    - 150 VDC, 130 ADC, 20 kW
    - Quantity: 1
  - EMHP40-600D42214
    - 40 VDC, 600 ADC, 30 kW
    - Quantity: 3
- **Spellman High Voltage Co**
  - High Voltage Power Supply
  - SL50PN1200/220
    - 50 kVDC, 24 mADC, 1200 W
    - Quantity: 1

LOAD

- **Resistive Load Banks**
  - 24 - 300 VDC, 100 ADC, 30 kW
  - Parallelable for higher power levels
  - Quantity: 2

  - 0 – 40 VDC, 360 ADC, 10 kW
  - Parallelable for higher power levels
  - Can be modified for higher voltages
  - Quantity: 2

LOAD

- **Kikusui Electronic Corp.**
  - Multifunctional DC Electronic Load
  - PLZ164W
    - 150 VDC, 33 ADC, 165 W
    - Quantity 20
  - PLZ1003WH
    - 500 VDC, 150 ADC, 1000 W
    - Quantity 10
- **NH Research Inc.**
  - High-Power / High-Current Electronic Load
  - 4700-6
    - 120 VDC, 1200 ADC, 6000 W
    - Parallelable for higher power levels.
    - Quantity: 5

BATTERY FACILITIES

Located Primarily in the Energy Systems Test Area – Bldgs 350, 354, & 354P

- Test battery performance (rate capability, cycle life test, thermal cycling and exposure, vacuum, vibration)
- Test battery safety (crush, drop, external short circuit, heat-to-vent, overcharge and overdischarge, vent and burst pressures)
- Provide long-term cold storage

• Associated infrastructure to accomplish the above includes trained, experienced personnel, approved procedures, safety equipment, test chambers, proper facility ventilation.. etc.

BATTERY TEST EQUIPMENT CAPABILITIES SUMMARY

- **Performance Testing:**
  - •10 V / 15 A - 36 channels
  - •30 V / 30 A - 9 channels
  - •15 V / 15 A - 12 channels
  - •50 V / 50 A - 4 channels
  - •5 V / 10 A - 2 machines with 12 channels
  - •80 V / 80 A with 12 channels (needs to be installed)
- **Abuse Testing:**
  - ▪2" and 4" Chamber: 0.1 to 700 psig
  - ▪4" Chamber: 10^{-3} torr to 700 psig
  - ▪2' Chamber currently being installed
  - ▪Crush testing (internal short simulator)
  - ▪Vent/burst testing (vent tester)
  - ▪TCEQ (Texas Commission on Environmental Quality)
  - ▪8Ch 15V /15A
  - ▪6Ch 40V / 30A
- **Environments:**
  - •Chambers from 2' to 15'
  - •Vacuum (1x10-6Torr to 100PSI).
  - •Thermal (-300°F to 500°F).
  - •Humidity control from 5% to 95%
- **Test Equipment:**
  - •Calibrators
  - •Scopes
  - •Digital Multimeters
  - •High Speed Data Systems
  - •Data Acquisition and Control Systems
  - •Thermal Imagers
  - •Microscope Camera System

BATTERY TESTING

- **Flight Testing:**
  - Acceptance testing on hardware before flight
  - Involves independent verification from Quality Control
  - Support many Shuttle and Station projects
- **Performance testing:**
  - Long and Short Term Cycling
  - Determine capacity of batteries
  - Determine optimal charge/discharge rates
  - Capacities at different thermal environments
  - Vacuum tolerance
- **Safety/Abuse Testing**

  (We do everything the label tells you not to):
  - Overcharge / Over discharge
  - Short Circuit
  - Thermal/Heat-to-Vent
  - Drop Test
  - Crush Test
  - Vibration
  - Vent/Burst

PERFORMANCE TEST EQUIPMENT

- **Automated Battery Test Stands**
  - 12 Systems ranging from 5 V to 500 V and 10 A to 600 A
  - Off-the-shelf units (Arbin, Maccor, PEC)
  - NASA constructed units (Labview)
  - Each channel is independent of the other
  - Can record voltage, current, and temperature
  - Constant voltage, current, and power modes

BATTERY TEST ENVIRONMENTS

- **Bell Jar Vacuum Chamber**
  - 10^{-4} torr
  - Pyrex see-thru design
  - Protective blast barrier
  - 16" diameter x 24" high

(pressures and rates of depress and repress are programmable)

- **Vacuum Environments**
  - 10^{-6} torr
  - 8ft and 15ft (Thermal Vacuum)
- **Thermal Chambers**
  - Various sizes ranging from 2ft to 8ft
  - Some have cryogenic capabilities of -300°F (-185°C)
  - Some chambers reach 500°F (260°C)
  - Precise humidity control
  - Unattended operation

BATTERY ABUSE CHAMBERS

- 2" and 4" Chamber: 0.1 to 700 psig
- 4" Chamber: 10^{-3} torr to 700 psig
- 2’ Chamber currently being installed
- TCEQ (Texas Commission on Environmental Quality)
  - approved purge of battery vent products
- Connected to:
  - Arbin 8Ch 15V /15A;
  - Labview 6Ch 40V / 30A

BATTERY ABUSE CAPABILITIES

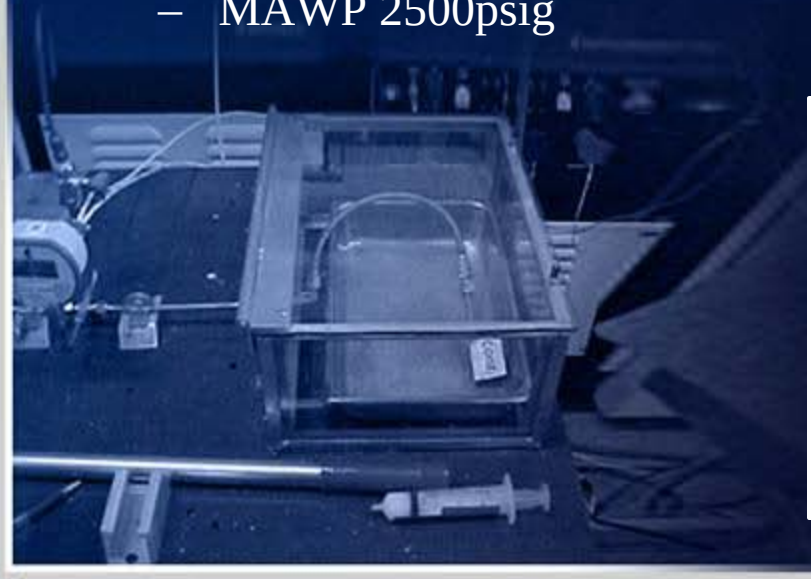
- **Drop Test Stand**
  - Trap door operated by solenoid valve connected to a remote switch behind blast wall.
  - 6" long x 7" wide trap door
  - Adjustable drop height of 0' to 8'
  - Video camera capability

BATTERY ABUSE CAPABILITIES

- **Crush Test Stand**
  - Operator protected by a blast wall
  - Simulates an internal short
  - Cause deformation without penetration
  - Can measure pressure of hydraulic system and calculate force
  - Monitor OCV and temperature
  - Video camera capability

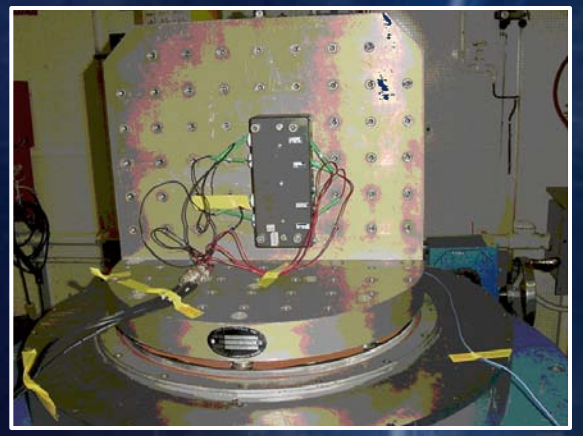
BATTERY ABUSE CAPABILITIES

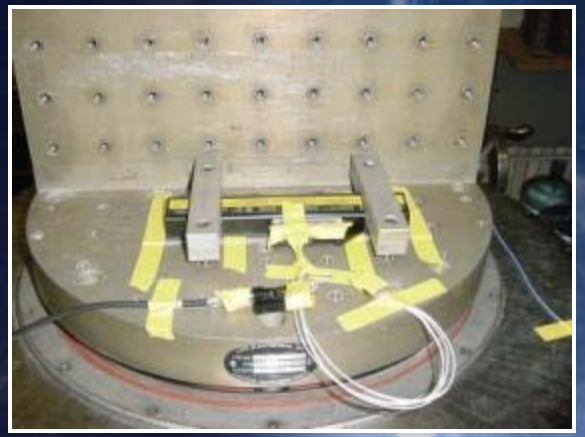
- **Vent/Burst Test Stand**
  - Can apply water pressure to battery and measure the pressure the battery vents.
  - Can block vent hole and measure the pressure the battery bursts
  - MAWP 2500psig



BATTERY ABUSE CAPABILITIES

- **Vibration**
  - Poorly constructed battery prone to internal shorts
  - Vibrate in the x, y and z axes to a defined spectrum
  - Cells and batteries undergo charge & discharge cycling before and after testing
- **Shock testing is also performed**

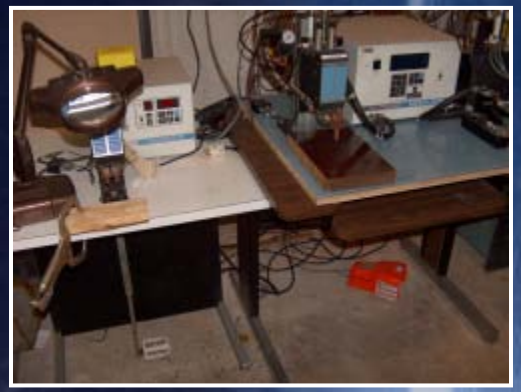




BATTERY TEST AREA RESOURCES

- **Walk-In Freezer**
  - Temperature range: -4°F to 80°F (-20°C to 27°C)
  - Usable envelope:
    - 40' long x 9.5' height x 8' width
    - 8' entrance with 2 swing doors
  - Temperature data recording
  - Alarm
  - Fire Protection System

- **Other Resources**
  - Spot welding (tabs onto cells for battery build-up
  - (for flight or just ground test)
  - Wet and Dry Chemistry Labs (GCs, IR, UV, HPLC,
  - Glove Box, Programmable oven, venthood,
  - microcalorimeter)



SUMMARY

- **What Do We Have To Offer:**
  - **40+ years of power and battery systems design, development and test expertise.**
  - **Facilities and resources designed to support power and battery systems development and testing.**
  - **Proven processes for the development and testing of all power system components.**
  - **Use of all resources from entire Energy Systems Test Area:**
    - **Local machine shop.**
    - **Local welding shop.**
    - **Local chemical analysis lab.**
    - **Local clean processing area.**
    - **Local in place calibration.**
    - **Land for buildups/materials lay down.**
    - **Controlled access**